REMARKS

Amendment summary

Upon entry of this Amendment, claims 9-13 and 15-40 will be pending.

Claims 37-40 are added. Support for these claims is found, e.g., in Example 5, pages 18-19 of the present specification.

No new matter is added by this Amendment, and Applicants respectfully submit that entry of this Amendment is proper.

Response to rejection of claims 9-13 and 15-36 under 35 U.S.C. § 103 based on Shoji in view of Hampl

In Paragraph No. 2 of the Office Action of September 25, 2006, claims 9-13 and 15-36 are rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Shoji et al. (U.S. Patent Application Publication No. 2006/0071051) in view of Hampl, Jr. (U.S. Patent No. 4,180,415).

Applicants respectfully submit that the cited prior art does not anticipate or render obvious the presently claimed invention. Even if a prima facie case of obviousness could be established based on Shoji and Hampl, which it cannot, the present invention provides for a combination of unexpectedly superior properties, including tensile elongation, tensile strength, and Vickers Hardness, which rebuts any prima facie case of obviousness and supports the patentability of the solder of the present invention.

Independent claim 9 recites a solder comprising zinc at 7 to 10 weight % both inclusive, bismuth at 0.001 to 6 weight % both inclusive, silver at X weight % wherein X is equal to or greater than 0.001, but smaller than 0.1, and the remainder of tin. The solder is lead-free. The solder has a combination of superior properties including improved tensile strength, breaking elongation, Vickers hardness, and shearing strength.

Applicants respectfully submit that Shoji does not anticipate or render obvious the presently claimed invention because Shoji (1) does not explicitly describe that Ag should be present in a solder at the presently claimed amount; and (2) teaches away from including Ag in a solder. Shoji discloses Ag as one of a number of generally contained impurities including as Pb, Ag, Sb, Cu, Fe, Al, As, and Cd. Accordingly, Shoji fails to explicitly describe that Ag, contained in a solder at 1 weight % or smaller, contributes to the improvement of solder characteristics, including improved tensile strength, breaking elongation, Vickers hardness, and shearing strength.

Applicants further note that Shoji teaches away from using Ag in a solder in the presently claimed amount. Shoji discloses that impurities (such as Ag) in a solder, when present in an amount of 1 weight % or smaller, do not exert a harmful influence on the characteristics of a solder. Shoji therefore teaches that such impurities <u>should not be contained in the solder</u>.

Accordingly, Shoji does not anticipate or render obvious the presently claimed invention because it fails to explicitly describe or suggest using Ag in the presently recited amount, and teaches away from using Ag in the presently recited amount.

With respect to Hampl, this reference does not cure the deficiencies in Shoji because (1) there is no reason to combine the teachings of Hampl in the manner set forth in the Office Action because Hampl discloses an electrode made from copper, rather than a tin-based solder such as that within Shoji; (2) there is no expectation of success from the combined teachings of Hampl and Shoji; and (3) Hampl teaches that Ag is an impurity, and therefore teaches away from the use of Ag in the presently recited amount.

The cited prior art does not render obvious the present invention because there is no reason to combine the teachings of Hampl and Shoji in the manner set forth in the Office Action. Applicants respectfully submit that it would not be obvious to combine the teachings of Hampl, which discloses a material used to make an electrode, with the teachings of Shoji, which discloses a material used to make a solder. In addition, it would not be obvious to combine Hampl with Shoji because Hampl discloses a material wherein copper is a principal constituent. The material disclosed in Hampl is therefore distinct from the tin used in the solder in Hampl, even if used in the same temperature profile.

Accordingly, there is no expectation of success from the combination of the two references. Assuming, *arguendo,* that Hampl teaches the use of Ag at 0.1 weight %, the use of Ag in the range of X weight % ($0.001 \leq X < 0.1$) in the Hample reference does not always provide the same advantages as those provided by the present invention, because, as mentioned above, the material to which Ag is added in Hampl is distinct from the material used in Shoji.

Further, similar to Shoji, Hampl discloses Ag as one of generally contained impurities such as Pb, Ag, Sb, Cu, Fe, Al, As, and Cd. Accordingly, Hampl fails to explicitly describe that

Ag, contained in a solder at 1 weight % or smaller, contributes to the improvement of solder characteristics, including improved tensile strength, breaking elongation, Vickers hardness, and shearing strength. Rather, Hampl discloses that impurities (such as Ag) in a solder, when present in an amount of 1 weight % or smaller, do not exert a harmful influence on the characteristics of a solder. Because Hampl teaches that lower amounts of impurities are beneficial, Hampl therefore implies that such impurities <u>should not be contained in the solder</u> at all.

In addition to the reasons above, Applicants submit herewith a Declaration Under 37 C.F.R. § 1.132 of Mr. Takuo Funaya, the first-named inventor of the present application, which illustrates the unexpectedly superior results achieved by the present invention.

Mr. Funaya explains that, with respect to the tensile elongation properties of a solder, if a solder is elongatable, then the solder may relax a stress when the solder is used for a long time under circumstances in which the solder is kept stressed. Accordingly, an elongatable solder may have a long lifetime.

FIG. 1 in the Declaration illustrates that, in comparison with a solder containing no Ag or containing Ag at 0.1 weight % or greater, the tensile elongation rate before fracture is significantly improved in the solder containing Ag at X weight % (where $0.001 \leq X < 0.1$), in particular, at Z weight % ($0.025 \leq Z < 0.1$).

With respect to tensile strength, FIG. 2 illustrates the tensile strength of a solder in a tensile test. The solder used in the tensile test contained Ag at Y weight %, Zn at 8 weight %, Bi at 1 weight %, and the remainder of Sn, wherein "Y" is a variable. FIG. 2 additionally shows data of a conventional solder including Pb at 37 weight % and the remainder of Sn, as reference

data. FIG. 2 shows that the tensile strength of the solder containing Ag at X weight % ($0.001 \leq X < 0.1$) is equal to or better than the tensile strength of a solder containing no Ag. In particular, the tensile strength of the solder containing Ag at 0.025 weight % and at 0.075 weight % shows its maximum peak, and is higher than the tensile strength of the solder containing no Ag or containing Ag in an amount of 0.1 weight % or greater. The tensile strength in the solder containing Ag at 0.05 weight % shows a minimum peak, but even that peak shows a tensile strength that is comparable to or greater than the tensile strength in a solder containing no Ag, when measurement dispersion is taken into consideration.

The Declaration, in FIG. 3, also shows that in a solder containing Ag at 0.1 to 0.5 weight %, Ag exerts slight influence on the tensile strength, and the tensile elongation is small. Accordingly, the data in FIG. 3 shows that the solder in accordance with the present invention has higher tensile strength and higher tenacity (because it is elongatable), and as a result has higher reliability than a solder containing Ag in an amount of 0.1 weight % or greater.

With respect to Vickers hardness, FIG. 3 of the Declaration, is a graph showing the Vickers hardness of a solder containing Ag at Y weight %, Zn at 8 weight %, Bi at 1 weight %, and the remainder of Sn, wherein "Y" is a variable. FIG. 3 also shows the Vickers hardness of a conventional solder including Pb at 37 weight % and the remainder of Sn, as reference data.

Mr. Funaya notes that one of the reasons why conventional Sn-Pb solder has been long used is its softness. Since a hard solder has little flexibility, a hard solder is likely to be cracked and then broken when subjected to an internal or external stress load. In contrast, a soft solder

can absorb internal or external stress by deforming. A soft solder can thereby present high reliability.

As illustrated in FIG. 3, the solder containing Ag at X weight % ($0.001 \leq X < 0.1$) is softer than a solder containing no Ag or containing Ag in an amount of 0.1 weight % or greater. Thus, FIG. 3 shows that the solder of the present invention has high tenacity.

With respect to Vickers hardness at high temperature, FIG. 4 of the Declaration is a graph showing how Vickers hardness of an ingot kept at 85°C in an electric furnace for more than 1000 hours varies. The Declaration shows that in the solder containing Ag at X weight % ($0.001 \leq X < 0.1$), a significant increase and reduction of the Vickers hardness of the ingot were not found. As Mr. Funaya explains, this means that the solder of the present invention keeps preferable flexibility as compared to a solder containing no Ag or containing Ag in an amount of 0.1 weight % or greater.

FIG. 5 of the Declaration includes SEM images of the samples used in FIG. 4 for measuring Vickers hardness, each sample containing Ag at Y weight %, Zn at 8 weight %, Bi at 1 weight %, and the remainder of Sn, wherein "Y" is a variable. As is understood from FIG. 5, a Zn-rich phase (the black contrast area in FIG. 5) was kept minute (i.e., very small) in the solder containing Ag at X weight % ($0.001 \leq X < 0.1$). In contrast, in a solder containing Ag in an amount of 0.1 weight % or greater, a Zn-rich phase grew large from the start of measurement, and even after the solder has been heated for 1000 hours. Mr. Funaya discloses that it is known that if a Zn-rich phase is large, then a brittle ZnO phase is formed (due to oxidization), which results in a reduction in the solder's strength.

Thus, the Declaration discloses that it is understood that a Zn phase is dispersed in the solder of the present invention containing Ag at X weight % ($0.001 \leq X < 0.1$), and hence, even if Zn is oxidized, a brittle ZnO phase is dispersed in the solder of the present invention. Furthermore, it is considered that solution of Ag would increase a strength of the solder.

The Declaration in FIG. 6 provides a graph showing the tensile strength of a solder containing Ag at Y weight %, Zn at 8 weight %, Bi at 1 weight %, and the remainder of Sn, wherein "Y" is a variable, and further showing the Vickers hardness of the solder, observed after the solder was kept heated at 85°C for 1000 hours. The area surrounded with a broken line "A" indicates solder in accordance with the present invention, containing Ag at X weight % ($0.001 \leq X < 0.1$), and the area surrounded with a broken line "B" indicates a solder containing Ag at Z weight % ($0.025 \leq Z < 0.1$). The tensile elongation in the area "A" is improved relative to a solder containing no Ag or containing Ag at 0.1 weight % or greater. In particular, the tensile elongation in the area "B" is improved relative to both a solder containing Ag at S weight % ($S < 0.025$) and a solder containing Ag at T weight % ($0.1 \leq T$). The Vickers hardness in the area "A" is smaller than a solder containing no Ag or containing Ag at 0.1 weight % or greater.

As set forth in the Declaration, the tensile strength in the area "A" is kept higher than the same of a conventional hazardous Sn-Pb solder, and is comparable to or higher than the tensile strength of a solder containing no Ag.

Furthermore, as discussed in the Declaration, it is possible to prevent a brittle ZnO phase from growing when the solder is kept at a high temperature by adding Ag into a solder at X

weight % ($0.001 \leq X < 0.1$). Accordingly, the lead-free solder in accordance with the present invention is elongatable and has high strength and high tenacity, as discussed in the Declaration.

For the reasons set forth above, the addition of Ag at X weight % ($0.001 \leq X < 0.1$) into a solder having the presently recited components is not disclosed or suggested by either Shoji or Hampl. In addition, the present invention provides unexpectedly superior results, in the form of improved characteristics, such as improved tensile strength, breaking elongation, Vickers hardness, and shearing strength. Accordingly, Applicants respectfully submit that the present invention is not obvious in view of the combined teachings of Shoji and Hampl. Applicants therefore respectfully request the reconsideration and withdrawal of this § 103 rejection.

Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

AMENDMENT UNDER 37 C.F.R. § 1.114(c)
Application No.: 10/516,708

Attorney Docket No.: Q85154

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

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Date: October 26, 2007